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BUREAU OF ENTOMOLOGY—BULLETIN No. 99.
L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON INSECTS INJURIOUS TO CITRUS AND OTHER SUBTROPICAL FRUITS.

CONTENTS AND INDEX.

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PAPERS ON INSECTS INJURIOUS TO CITRUS AND OTHER SUBTROPICAL FRUITS.

I. THE ORANGE THRIPS:
A REPORT OF PROGRESS FOR THE YEARS 1909 AND 1910.

By P. R. JONES AND J. R. HORTON,
Agents and Experts, Deciduous Fruit Insect Investigations.

II. THE RED-BANDED THRIPS.

By H. M. RUSSELL, *Entomological Assistant.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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ERRATA.

Page 17, line 4 from bottom, after *Marchal* strike out *Craw*.

Page 17, line 9 from bottom, for *Physophus* read *Physopus*.

Page 18, line 19 from bottom; page 21, line 3; page 28, lines 7 and 10 from bottom; page 29, lines 11, 13, 15, 19, 33, for *Physophus* read *Physopus*.

Page 28, lines 7 and 10 from bottom, for *rubrocinctus* read *rubrocincta*.

U. S. D. A., B. E. Bul. 99, Part I. D. F. I. I., March 6, 1911.

PAPERS ON INSECTS INJURIOUS TO CITRUS AND OTHER SUBTROPICAL FRUITS.

THE ORANGE THRIPS: A REPORT OF PROGRESS FOR THE YEARS 1909 AND 1910.

By P. R. Jones and J. R. Horton,[a]

Agents and Experts, Deciduous Fruit Insect Investigations.

INTRODUCTION.

The orange thrips (*Euthrips citri* Moulton), a small, yellow, active insect belonging to the order Thysanoptera (popularly known as thrips), scars the fruit and curls and distorts the leaves of the orange. At the present time its control constitutes the chief insect problem confronting the citrus growers of the San Joaquin Valley orange belt of California, which winds along the Sierra Nevada foothills, from east of Fresno to south of Delano. This insect, the work of which was first noticed 15 or 16 years ago, has increased in numbers with the growth of the citrus industry and recently has assumed serious economic importance.

At the urgent request of a number of orange growers of Tulare County, an investigation of the insect was begun the latter part of April, 1909. The present paper is a preliminary report of the results obtained during the seasons 1909 and 1910.

The writers wish to acknowledge the financial assistance of the Tulare County board of supervisors, the Lindsay Citrus Growers' Protective League, and the Tulare County Fruit Exchange; they desire to acknowledge the kindness of Messrs. P. M. Baier, Harry Postlethwaite, and R. H. Shoemaker in allowing the Bureau of Ento-

[a] The investigation of the orange thrips by members of the force engaged in studies of deciduous-fruit insects appeared desirable, because these men were familiar with a closely related species—the pear thrips—which is very destructi to prunes, pears, cherries, etc., in the San Francisco Bay region. However, in order to keep together the articles dealing with insects damaging citrus and other subtropical fruits, the present paper is published in a series of articles dealing with insects of that class.—A. L. Quaintance, *in Charge of Deciduous Fruit Insect Investigations.*

mology the use of their orchards for experimental and demonstration purposes; and they would express their indebtedness to the large number of orange growers in Tulare County who have put into effect in their own orchards the recommendations of the Bureau, thereby demonstrating the value of the spraying treatments advised.

ORIGINAL HOME AND DISTRIBUTION.

The orange thrips is probably native to North America. Its natural habitat is probably the Sierra Nevada foothills or the adjoining plains of the southern San Joaquin Valley, and it was no doubt attracted from its natural food plants by the more succulent and luxuriant orange trees. This insect is distributed throughout the entire orange belt of the San Joaquin Valley and has been collected in several places in Southern California and at Phoenix, Ariz., by the senior author. The infestation in Arizona embraces orange groves in the Salt River Valley surrounding Phoenix, and was reported upon by Prof. J. Eliot Coit in a bulletin of the Arizona Agricultural Experiment Station.[a] This gentleman, in sending specimens to Dr. W. E. Hinds for identification, probably did not obtain the true orange thrips (*Euthrips citri* Moulton), but some specimens of *Euthrips occidentalis* Pergande, which is found occasionally upon citrus trees, but which rarely causes any serious injury. The true orange thrips was described as a new species by Mr. Dudley Moulton in a bulletin of the United States Department of Agriculture, issued February 11, 1909.[b]

The orange thrips has also been reported from Hermosillo, Sonora Province, Mexico, but the writers have not been able to obtain specimens from that locality.

The occasional scarring of oranges in the north-central portion of California is caused by the grain thrips (*Euthrips tritici* Fitch), and not by the orange thrips.

FOOD PLANTS.

Although the orange thrips, when described, was thought to infest only citrus trees, the writers have taken it from a number of other host plants. The following list shows the wide range of food plants upon which this insect can exist:

Of citrus fruits the following are affected: *Citrus aurantium* var. *sinensis* (Washington Navel, Australian Navel (?), Thompson Improved, Valencia Late, Mediterranean Sweet, Parson Brown, Ruby

[a] Arizona Agricultural Experiment Station, Bulletin No. 58, Citrus Culture in the Arid Southwest, p. 319, 1908.

[b] U. S. Department of Agriculture, Bureau of Entomology, Technical Series No. 12, Part VII.

Blood, St. Michael, Homosassa, and seedlings); *Citrus nobilis* (Satsuma and tangerines); *Citrus decumana* (grapefruit); *Citrus medica* var. *limon* (lemon); *Citrus medica* var. *acida* (lime, varieties of); and *Citrus japonica* (kumquat).

The following miscellaneous plants are infested: *Punica gramatum* (pomegranate); *Vitis vinifera* (European grape, varieties of); *Schinus molle* (California pepper tree); "umbrella tree;" *Pyrus communis* (pear); *Prunus armeniaca* (apricot); *Prunus persica* (peach); *Prunus domestica* (European plum, varieties of); *Salix* sp. (willow); *Rumex* sp. (dock); *Portulaca oleracea* (purslane); *Olea europea* (olive); *Rubus idæus* (red raspberry); *Rosa* sp. (rose); *Solanum* sp.

CHARACTER AND EXTENT OF INJURY.

Injury to citrus trees and fruit is caused directly by the feeding of both adults and larvæ upon the surface of the parts attacked. This feeding may be on the young fruit (Plate I, figs. 1, 2), the nearly mature fruit (Plate II), or the new, tender foliage (Plate III), and generally takes place on all of these. The injury to foliage is generally on young leaves, but may also occur on the axillary buds.

The manner of feeding of both the adult and larva of the thrips is identical, and consists in piercing the plant tissues with the sharp mouthparts with which both stages are equipped and then rasping the wound by a "rooting" motion of the head. The vegetable juices thus liberated from the plant cells are sucked into the alimentary canal of the insect. The characteristic marking or scabbing of the fruit, so noticeable at picking time, is started when the fruit is very small—just after the petals have fallen from the blossoms. This scabbed area is small at first, but as the fruit grows and the thrips continue to feed the markings deepen and at the same time the area of injury is enlarged. The continued feeding of a large number of thrips results in the scabbing of nearly the entire surface of the fruit. Often the marking is so large and deep over a portion of the orange that it causes the fruit to be misshapen and aborted. Frequently the entire surface is scarred while the fruit is still small, with the result that it ceases to grow and falls from the tree.

Orange trees in the Tulare County citrus belt make about four distinct growths a year, and it is on this tender foliage that the orange thrips multiply in greatest numbers. The feeding of large numbers of these little insects causes the young leaves to curl and become distorted and the whole growth to present a sickly appearance. Young trees are often held back a year or more in growth by the prompt destruction of the terminal buds soon after these make their appearance.

DESCRIPTION AND LIFE HISTORY.

THE ADULT.

The adult female of the orange thrips is a small, four-winged, orange-yellow insect, which moves very rapidly by running, leaping, and flying. The mouthparts, which are suctorial in nature, form a sharp cone projecting from the underside of the head. The adult male is smaller than the female and much more rapid in its movements.

The original description of the adult female by Moulton[a] is as follows:

Euthrips citri n. sp.

Measurements: Head, length 0.75 mm., width 0.15 mm.; prothorax, length 0.09 mm., width 0.18 mm.; mesothorax, width 0.24 mm.; abdomen, width 0.25 mm.; total body length 0.86 mm. Antennæ: I, 12μ; II, 36μ; III, 39μ; IV, 39μ; V, 30μ; VI, 34μ; VII, 6μ; VIII, 12μ; total, 0.205 mm. *Color*, yellow to orange-brown, with thorax and segment 2 of antennæ more noticeably orange-brown.

Head twice as wide as long, retracted considerably into the prothorax, broadly rounded in front, with only slight depressions to receive the basal joints of the antennæ; two spines on anterior margin, other spines not conspicuous; cheeks almost straight and parallel. *Eyes* large, occupying almost one-half the length of the head, prominent; pigment deep red to purple; facets of eyes large, eyes pilose. Ocelli subapproximate, margined inwardly with yellow-brown crescents. *Mouth-cone* short, reaching almost to posterior margin of prothorax, broadly rounded and with black spot at tip; maxillary palpi 3-segmented. *Antennæ* 8-segmented, with segment 2 orange-yellow, other segments uniformly light brown; segments 2, 4, 5, and 6 almost equal in length; style about one-half the length of segment 6. All spines inconspicuous; sense cones transparent.

Prothorax about twice as wide as long, posterior angles broadly rounded; with long brown and outer small spine at each posterior angle, other spines not conspicuous. *Mesothorax* largest and with anterior angles broadly rounded. *Legs* light yellow-brown, with tarsi lighter but dark brown at the tip; spines on legs brown. *Wings* present and fully developed, forewings broadest near base and pointed at tips; with the ring vein and a single longitudinal vein which divides at about one-third the length of the wing from the base, the anterior part running parallel and approximate to the anterior part of the ring vein, and ending abruptly near the tip, the posterior paralleling and approaching the posterior part of the ring vein and ending about one-half the wing's length from the end, each branch with a dark-brown marking immediately at its tip. The costa bears a row of about 29 regularly placed spines. Other spines placed as follows: A group of 5 near base of median longitudinal vein; 2 on either side of where second vein branches from the first, and 3 scattered spines about equidistant on each branch vein and in each case one of these spines immediately at the end of the vein; several rather long spines on scale. Veins of the forewing unusually strong and conspicuous, somewhat orange colored near base but fading to yellow near tip. Membrane of wings transparent.

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[a] Loc. cit.

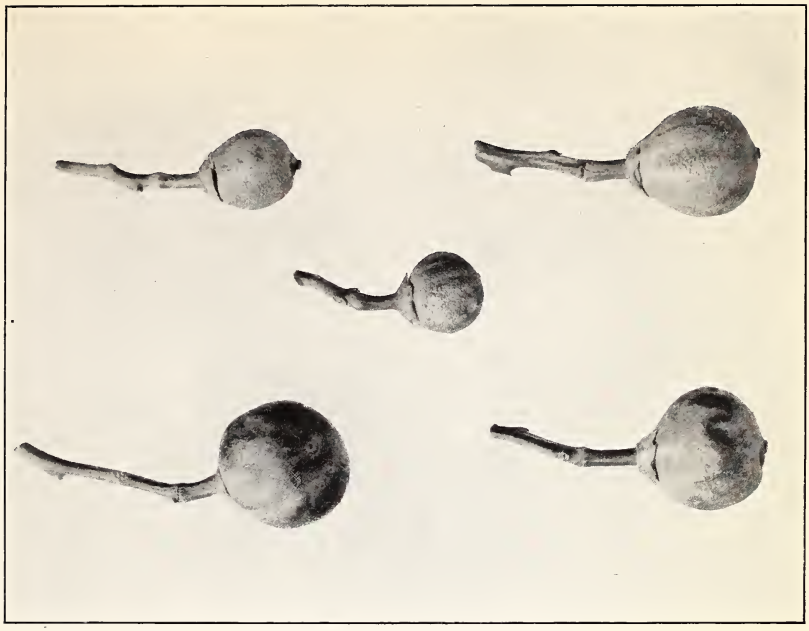


FIG. 1.—YOUNG ORANGES, SHOWING INJURY BY THE ORANGE THRIPS (EUTHRIPS CITRI). SOMEWHAT ENLARGED. (ORIGINAL.)

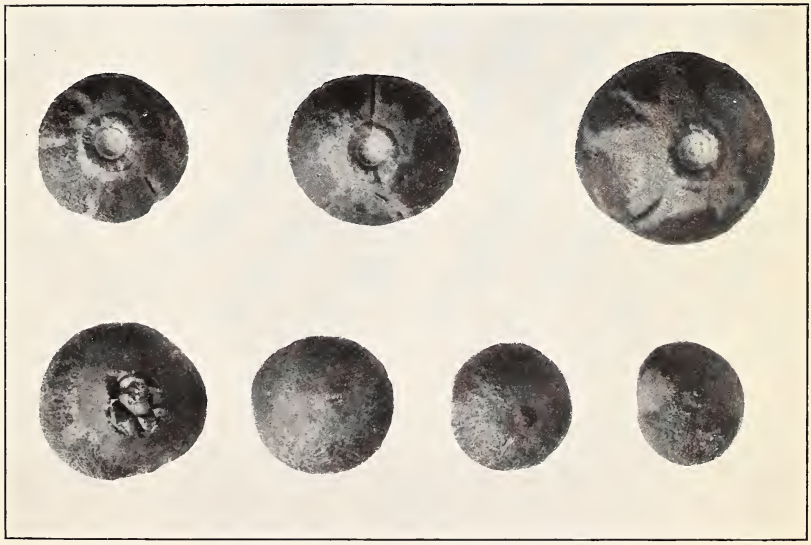


FIG. 2.—YOUNG ORANGES, SHOWING INJURY TO STEM AND BLOSSOM ENDS BY THE ORANGE THRIPS (EUTHRIPS CITRI). SOMEWHAT ENLARGED. (ORIGINAL.)

MATURE ORANGES, SHOWING INJURY DUE TO THE ORANGE THRIPS. (ORIGINAL.)

ORANGE FOLIAGE, SHOWING CURLED AND DISTORTED CONDITION OF LEAVES DUE TO WORK OF THE ORANGE THRIPS. (ORIGINAL.)

Abdomen ovoid, tip conical, all spines, excepting a very few at tip, inconspicuous.

Described from many female specimens collected from orange foliage and fruit at Exeter, Tulare County, Cal.

The males are similar to the females, but smaller and more active, with the orange-colored testes prominent.

THE EGG.

The egg is a bluish white, bean-shaped object measuring from 0.2 mm. in length to about 0.075 mm. in width, with a very thin shell.

THE LARVA.

First-stage larva.—Length 0.041 mm.; width of mesothorax 0.011 mm.; general shape fusiform. The antennæ, head, and legs are large and unwieldy in proportion to the rest of the body. Color translucent white. *Antennæ*, length 0.015 mm.; distinctly 4-segmented; I short, cylindrical; II more than twice as long as I, slightly urn-shaped, longer than wide; III about as long as II, obtusely fusiform; IV about as long as the other joints combined, fusiform, very finely drawn out at the distal end. Segments II, III, IV (II very obscurely) ringed, the distal rings on segment IV appearing as segmental divisions. A few fine hairs present on all segments, most numerous on IV but not very conspicuous on any of the segments. *Head* subquadrate; eyes reddish-brown. *Abdomen* gradually tapering, 10-segmented, first 8 segments subequal; IX and X large and more abruptly tapering, hairs inconspicuous. *Legs* stout, femora and tibiæ nearly equal in length, tarsi one-jointed, ending in a single claw.

Second-stage larva.—Length 0.9 mm.; head length 0.1 mm.; width 0.083 mm.; length of antennæ 0.175 mm.; width of mesothorax 0.266 mm.; width of abdomen 0.3 mm.; *Antennæ*, I, 2μ; II, 3μ; III, 9μ; IV, 45μ; V, 9μ; VI, 15μ; color orange-yellow. In shape similar to first-stage larva except that the abdomen is oval to ovate and generally more robust. *Head* quadrate, small in proportion to body, eyes reddish. Antennæ apparently 4-segmented under 2/3 objective, but under 1/6 objective distinctly 6-segmented, the chitin not extending into the fifth and sixth segments; I short, conical, about as broad as long; II cylindrical, broader than long and slightly longer than I; III obtusely spindle-shaped, about twice as long as broad and about as long as I and II combined; IV obtusely spindle-shaped but blunt on the distal end, about as long as III; V very short and thick, slightly broader than long, about one-fifth as long as IV; VI cylindrical, longer than broad, about one-third as long as IV. *Abdomen* oval to ovate, 10-segmented, the last segment tubular. *Legs* short and stout, hind femora and tibiæ about equal, hairs everywhere inconspicuous except a few under 1/6 objective, which are the most prominent on last segments of antennæ.

THE PUPA.

First-stage pupa.—Length 0.56 mm.; width of head 0.15 mm.; width of mesothorax 0.18 mm.; width of abdomen 0.25 mm.; antennæ, length 0.2 mm. Color pale translucent yellow; antennæ, legs, and wing-pads lighter. Shape similar to advanced first-stage larva; abdomen elongate ovoid. Antennæ projecting cephalad, 4-segmented; I short, thick, slightly wider than long; II obtuse, urn-shaped, about as wide as long; III obtusely spool-shaped, about as

long as I and II combined and about twice as long as wide; IV about as long as III, tapering to obtuse apex. Wing-pads extending to distal margin of the second abdominal segment, those of hind wings slightly longer. Legs stout, hind femora and tibiæ about equal. Hairs present on live specimens but not prominent, short, slightly longer on tip of abdomen.

Second-stage pupa.—Length 0.666 mm.; width of head 0.133 mm.; width of prothorax 0.133 mm.; width of mesothorax 0.166 mm.; width of abdomen 0.133 mm. Shape similar to that of the adult. Color translucent white to pale yellowish; eyes reddish, more prominent than in first-stage pupa. Antennæ 4-segmented, projecting backward over the head and thorax and reaching to the middle of the prothorax, second segment forming a kind of elbow from which 3 or 4 long setæ project cephalad. Prothorax nearly twice as broad as long; wing-pads in pupæ just entering the second pupal stage extending to the distal margin of the sixth abdominal segment; in pupæ in which the adults are nearly ready to emerge the wing-pads extend to the distal margin of the ninth abdominal segment. Abdomen similar in shape to that of the adult. Legs stout, hind femora and tibiæ about equal in length, setæ more prominent than in first-stage pupa, longer at the tip of the abdomen; conspicuous in fresh specimens but not in mounted ones. Tip of abdomen often with a cremaster-like formation resembling in shape a fork with 4 tines. Male pupæ smaller, resembling the adults, their wing-pads usually reaching past the tip of the abdomen. Setæ usually not so prominent.

SEASONAL HISTORY.

The orange thrips passes the winter in the adult state, and it is generally the adult form which first becomes conspicuous upon the orange trees in the spring. Although no large number of adults has been collected in hibernation, these undoubtedly pass the winter in sheltered places, such as the dead leaves and twigs forming the trash under most orange trees; they are occasionally found on living plants and on citrus nursery stock in midwinter.

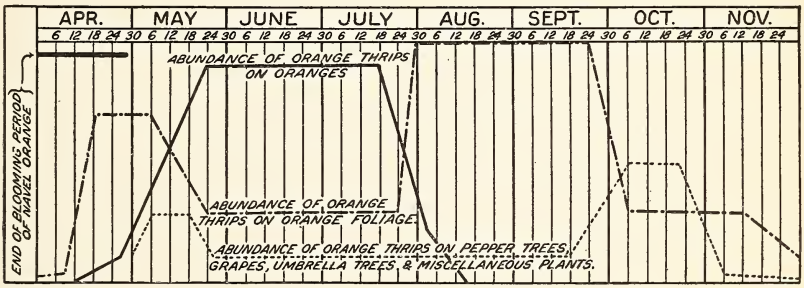
Adult thrips appear in limited numbers during March. They deposit very few eggs in the early part of April, prior to the blossoming of the Navel orange trees, but soon after most of the petals have fallen larvæ become quite numerous. Oviposition has not been observed, but it is probable that it takes place mostly at night. Examinations for eggs revealed the fact that most of them are placed in the new, tender growth, being inserted into both upper and lower leaf surfaces, and also in the shoots. They are also placed in the receptacles of the blossoms after the petals have fallen and in young fruit and fruit stems.

The larvæ are wingless and when full grown are orange colored. When ready to pupate they fall from the trees, get into a curled dead leaf, amid cobwebs, dust, and leaf particles, and hide until the transformation is completed. Pupæ are not found in numbers proportionate to the larvæ and adults, since it is in this stage that the mortality rate of the insect is greatest. The pupæ are very soft-bodied and less active than larvæ and adults. They move readily, however, when disturbed.

Eggs, larvæ, and adults are found on the trees, and pupæ in the dead leaves under them, from early May until early November, all four forms being present during the entire period. The broods thus overlap so closely that it is very difficult to separate them.

INTERRELATION OF ABUNDANCE OF THRIPS AND FOOD PLANTS.

The orange thrips feed only on very tender plant tissues, namely, the young leaves, shoots, and tender fruit. This makes it necessary for them to pass from foliage to fruit and from plant to plant as the suitability of the tissues as food changes. They first make their appearance in April and May on the new growth of the Navel orange, reaching the first maximum of abundance about the time four-fifths of the petals are off. When most of the petals have fallen a few thrips pass to the more advanced fruit and the number feeding on the latter rapidly increases as the first growth of foliage becomes hardened and distasteful. The thrips continue feeding on the fruit until the latter, in turn, becomes somewhat tough, and reach a second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ABUNDANCE OF ORANGE THRIPS ON ORANGES
END OF BLOOMING PERIOD OF NAVEL ORANGE
ABUNDANCE OF ORANGE THRIPS ON ORANGE FOLIAGE
ABUNDANCE OF ORANGE THRIPS ON PEPPER TREES, GRAPES, UMBRELLA TREES, & MISCELLANEOUS PLANTS.

FIG. 1.—Diagram illustrating the relative abundance of orange thrips on oranges, on orange foliage, and on other plants during the season. (Original.)

and greater maximum in May, June, and July. They then pass once more to the succulent growth which has come on in the meantime, and reach the third and final maximum of concentration in August and September.

As the first citrus growths are becoming tough and before the fruit is quite tender, the thrips begin to work on the leaves of the grape, pepper tree, umbrella tree, and some uncultivated plants, reaching a minor maximum of abundance on these at the time of greatest abundance of tender leaves and stems. A second maximum of concentration is reached on some of these secondary food plants in the fall, when most all of the summer growths on citrus trees have become tough.

The relative abundance of the orange thrips on its various food plants, at different times during the season, is shown diagrammatically in the accompanying chart (fig. 1); the diagram represents the results of observations made at regular intervals in different parts of the Tulare County citrus belt.

LIFE CYCLE.

In ascertaining the length of the life cycle the average lengths of egg, larval, and pupal stages were added together, and to this an additional 3 days, which was the usual time from the appearance of the adult female until ovipositing began. The life cycle thus includes the period from egg to egg, or from the time the egg has left the abdomen of the female of one brood until the eggs of the next brood appear.

Egg stage.—The length of the egg stage was determined by confining adult thrips on potted orange plants overnight, then removing all insects and examining the plants twice daily, and counting the larvæ hatched until they cease to appear. The length of the egg stage of 19 eggs during the month of August, 1909, was found to be 2½ days for a minimum and 8 days for a maximum, with an average of 6.2 days. Eggs deposited the latter part of September required from 20 to 24 days for incubation. During May, June, July, and August, 1910, observations on 45 eggs gave a minimum of 5 days, a maximum of 13 days, and an average of 8.1 days for 3 months. It is probable that the majority of eggs deposited during May, June, July, and August would require from 6 to 8 days for incubation, while in March, April, September, and October the length of the egg stage would be considerably more.

Larval stage.—The number of days required for the development of the larva varied from a minimum of 3 days to a maximum of 13 days, with an average of 6.06 days for 55 individuals; and a minimum of 3 days, a maximum of 13 days, and an average of 7.2 days for 73 individuals during April, May, June, July, and August. The length of the larval stage would probably be extended, similar to the egg stage, during September and October. Two distinct larval stages were observed. The first stage is usually about two-thirds as long as the second, and the larvæ more active.

Pupal stage.—The pupal stage was best observed by keeping larvæ in confinement until they pupated. The total length of the pupal instar for 30 individuals, under observation during June and July, 1909, varied from 2 to 5 days, with an average of 3.6 days; while 287 observations during April to August, 1910, gave a variation of 2 to 7 days, with an average of 4.8 days. Two pupal stages were observed, there being a distinct molt from the first to the second stage, which begins with a splitting of the skin from the head back dorsally to about 7 to 9 abdominal segments. The pupæ are more active in the first than in the second stage.

Total life cycle.—The life cycle, obtained by adding the average lengths of egg, larval, and pupal stages, and allowing 3 days

before eggs were deposited by the newly formed adults, made a total of 18.68 days for May to August, inclusive, 1909. For the months April to August, inclusive, 1910, this period was 23 days. The length of the life cycle of 8 individuals actually recorded from the egg, upon potted plants, allowing 3 days, as before, for the adults to oviposit, varied from 20 to 36 days. The data upon the 8 individuals was obtained during September and October, and the life cycle was undoubtedly longer at this time than in midsummer. The length of life of the adults observed on confined individuals was from 4 to 36 days.

Number of broods.—Although the number of generations in a season has not been definitely observed, there are probably four and a partial fifth during the period of May to July, inclusive, and one generation in each of the months March, April, August, September, and October, making in all a possibility of eight to ten generations for the season.

HABITS.

The orange thrips is very active, especially in the adult form. Its ability to run, leap, and fly is much greater than that of any other thrips so far observed by the writers. This activity and their small size allow them easily to pass unobserved. The writers have frequently seen adults fly from one tree to another 20 feet or more distant. They undoubtedly move about to a certain extent, and will go from one orchard to another in search of suitable food. Frequently they will desert the orange groves, between periodical growths, for grapes and certain deciduous fruits.

The orange thrips appear to thrive best in sunny and even very hot weather. On cool cloudy days they are less active and generally group themselves on the underside of the leaves.

Their reproductive habits are only partially understood. Males are present part of the year, but usually in more limited numbers than the females.

EXPERIMENTS WITH METHODS OF CONTROL.

CULTIVATION.

Attempts have been made to control the orange thrips, in part, by means of cultivation, but none of these endeavors has been in the least successful. One orchard was hand-raked under the trees and the soil stirred up in the fall, with the hope that pupæ would be destroyed, but results were negative. Another orchard which was plowed deeply in the fall yielded similar results.

FUMIGATION.

Some experiments have been conducted in the hope that fumigation with hydrocyanic-acid gas would prove effective in controlling the orange thrips, but all results have been unsatisfactory, because of the activity of the insects, the large number of generations, and the expense of the operation.

SPRAYING.

The only method of control which has given good results is spraying at high pressure with a contact insecticide. No sprays aside from those which kill by contact have been tried because such sprays have been unsuccessful in controlling other species of injurious thrips.

Experiments to Determine Killing Effect of Different Sprays.

The following sprays were tested in the field for killing effect on the thrips: Homemade distillate-oil emulsion, in combination with black-leaf tobacco extract, which is a dark, almost viscid liquid containing $2\frac{3}{4}$ per cent nicotine; and commercial lime-sulphur (33° Baumé) in combination with the tobacco extract. All sprays were applied with a hand pump, maintaining a pressure of 140 pounds. A large number of young fruit was examined for live and dead thrips. While this method did not give absolutely accurate results, because of the number of thrips knocked off by the force of the spray, it offered some means of comparison. Table I shows the relative killing effect of the various washes:

Table I.—*Killing effect of various sprays on orange thrips.*

Number of fruits examined.	Formula.	Total number of thrips counted.	Number of thrips dead.	Percentage of thrips dead.
150	Blackleaf 1–50 and distillate-oil emulsion 1 per cent	129	126	97.6
200	Blackleaf 1–60 and distillate-oil emulsion 1 per cent	182	170	93.4
100	Blackleaf 1–80 and distillate-oil emulsion 1 per cent	67	64	92.5
Several hundred	Blackleaf 1–85 and distillate-oil emulsion 1 per cent	.....	.....	75
Do	Commercial lime sulphur 1–75 and blackleaf 1–50	.....	.....	90
Do	Commercial lime-sulphur 1–50 and blackleaf 1–100	.....	.....	95

Experiments to Prevent Marking of the Fruit.

Experiment No. I.—A block of 150 Washington Navel orange trees was sprayed three times with distillate-oil emulsion and black-leaf tobacco extract; the former at the strength of 2 per cent and the latter in the proportions of 1 to 80 and 1 to 100 parts of spray. The spraying was tried as a means of preventing the thrips from curling the tender foliage and marking the young fruit. The first application was made May 4, 1909, after most of the petals had fallen

and when both larvæ and adults were present. The second application was made eight days later, and the third three weeks after the second, at which time the thrips began again to be numerous. All the spraying was done with a hand outfit, maintaining a pressure of 140 pounds.

In recording the results of the spray applications to ascertain their efficiency it was necessary to class the fruit, as regards injury, in four grades, as follows:

Sound: No thrips marking.

Slightly marked: A slight marking at one end or a few streaks on the surface.

Moderately marked: Both ends of fruit marked and some scabbing on the rest of the surface.

Badly marked: Nearly one-half to three-fourths of the surface marked, often with misshapen fruit.

At picking time 20 loose, or "lug," boxes of oranges from the sprayed trees and 20 from an adjoining block of unsprayed trees were counted. The results obtained are given in Table II.

TABLE II.—*Injury to sprayed and unsprayed fruit by orange thrips.*

SPRAYED.

Number of loose boxes.	Total number of oranges examined.	Number sound.	Number slightly marked.	Number moderately marked.	Number badly marked.	Per cent of sound fruit.	Per cent of slightly marked fruit.	Per cent of moderately marked fruit.	Per cent of badly marked fruit.
20	2,070	1,533	506	31	.....	74.5	24.5	1	0

UNSPRAYED.

20	2,365	337	1,047	710	271	14.5	44.5	30	11

A commercial grading of the sprayed fruit would have placed nearly 75 per cent as "Fancy" and the remainder as "Choice," while the unsprayed fruit would have run not more than 15 per cent "Fancy" and 50 per cent "Choice," the remainder going out as "Standards" and "Culls." Of the fruit counted from the unsprayed trees, 85.5 per cent was marked, while 25.5 per cent only of that from the sprayed trees showed injury, indicating that 60 per cent of the sound fruit was due to the spraying. The thrips-marked fruit was smaller than the sound fruit, as will be seen by comparing the total number of oranges from the 20 boxes of sprayed fruit with that from the 20 boxes of unsprayed fruit. The writers have frequently noticed in the packing houses that the smaller fruit is worse marked than the larger, making it appear that the thrips injury holds back the growth of the oranges.

The sprayed block contained 121 bearing trees. These yielded 165 loose boxes of oranges. The unsprayed block contained 152 bearing trees, which yielded 162 loose boxes of oranges. The sprayed block, therefore, produced three more boxes of fruit, though containing 31 less trees, than the unsprayed block.

Experiment No. II.—A block of Washington Navel oranges embracing about 5 acres was selected in the spring of 1910 and treated three times with a spray of commercial lime-sulphur (33° Baumé), 1 part to 75 of water, combined with blackleaf tobacco extract, 1 to 150. A gasoline power sprayer was used and a pressure of 200 pounds maintained. The first application was made May 4, the second May 17, and the third June 14. The first application was timed at a date when most of the petals had fallen. The second and third applications were made when the thrips became sufficiently numerous. An effort was made to keep the young fruit free from thrips until it was the size of an English walnut, as it appeared that this would insure a high percentage of clean fruit.

Examinations and counts made of 92 loose boxes of sprayed fruit and 20 loose boxes of unsprayed fruit from an adjoining unsprayed "check" block gave the results shown in Table III.

TABLE III.—*Injury to sprayed and unsprayed fruit by orange thrips.*

SPRAYED.

Number of loose boxes.	Total number of oranges examined.	Number sound.	Number slightly marked.	Number moderately marked.	Number badly marked.	Per cent of sound fruit.	Per cent of slightly marked fruit.	Per cent of moderately marked fruit.	Per cent of badly marked fruit.
92	8,458	4,995	3,383	68	12	59	39.9	1	0

UNSPRAYED.

20	1,697	498	1,108	65	26	29.3	65.2	3.8	1.5

The sprayed fruit shows a total of 40.9 per cent marked, while 71 per cent of the unsprayed fruit was marked, and more severely. The amount of benefit due to the spraying was 30.1 per cent, which was considerably less than in 1909, due to the fact that the thrips were more numerous and infestation worse in 1909. The total output of oranges from Tulare County in 1910 was 50 per cent freer from thrips markings than in 1909.

EXPERIMENTS WITH NURSERY TREES.

Several blocks of young nursery trees were sprayed in the fall of 1909 with commercial lime-sulphur, 1 to 75, combined with blackleaf tobacco extract, 1 to 150. By two thorough applications it was

possible to save the tender foliage and axillary buds and to promote a growth of 1 to 2 feet more on the sprayed trees than on those unsprayed.

Spray Injury.

While no actual spray injury, immediate or cumulative, developed from the use of distillate-oil emulsion and blackleaf tobacco extract at the strengths indicated above, the uncertainty of this combination as compared with the lime-sulphur and blackleaf tobacco extract led to the adoption of the latter as a spray for demonstration work during the season of 1910.

RECOMMENDATIONS.

In view of the success attained in reducing injury to fruit and foliage by the orange thrips, it is believed that it will be possible to control this species in normal seasons with four applications of lime-sulphur combined with blackleaf tobacco extract.

TIME OF APPLICATION.

Three of the treatments should be made in the spring to free the fruit and spring growths of foliage from injury, since the more severe marking of fruit is done while the fruit is small. The fourth treatment should be made in August or September, according to season, for the protection of the later growths of foliage, and should be timed to catch the thrips when numerous, but before the leaves show much curling. The three spring applications should be made about as follows:

First. Just after most of the petals have fallen from the blossoms.
Second. Ten to fourteen days after the first.
Third. From three to four weeks from the time of the second treatment.

The dates for spraying in any given season must be timed by the abundance of thrips.

SPRAY DILUTIONS.

Lime-sulphur solutions should be diluted according to density. In the homemade product this may be determined by the use of a Baumé or a specific gravity spindle. The density of the commercial product will be stated by the manufacturer or may be obtained by the use of the spindle.

Lime-sulphur solution of a density of 33° Baumé should be diluted at the rate of 1 volume to 75 volumes of water; that of a density of 36° Baumé should be diluted at the rate of 1 volume to 86 volumes of water. Therefore the formula for orange-thrips spraying would be:

(1) Lime-sulphur (33° Baumé) 1 to 75 and blackleaf tobacco extract (2¾ per cent nicotine) 1 to 100; or, using blackleaf "40" (40 per cent nicotine) tobacco extract 1 to 1,800.

(2) If lime-sulphur of 36° Baumé is used the formula would be, lime-sulphur 1 to 86 and blackleaf tobacco extract 1 to 100; or blackleaf tobacco extract "40" (40 per cent nicotine) 1 to 1,800.

To load a sprayer having a 200-gallon tank, proceed as follows: First turn water into the tank until nearly full, add 2⅔ gallons lime-sulphur (33° Baumé) and 2 gallons blackleaf tobacco extract (2¾ per cent nicotine); or 14 fluid ounces blackleaf "40" tobacco extract (40 per cent nicotine). If the lime-sulphur is 36° Baumé, use 2.1

FIG. 2.—Power spraying outfit in use in spraying for the orange thrips. (Original.)

gallons, and 2 gallons of blackleaf tobacco extract; or 14 fluid ounces of blackleaf "40" tobacco extract.

HOW TO SPRAY.

In spraying for the orange thrips only those insects actually hit with the spray will be killed. As this insect obtains its food by sucking the plant juices, stomach poisons are of no avail. In order to spray with greatest efficiency it is necessary to use a gasoline power sprayer, maintaining a pressure of 180 to 200 pounds. (See fig. 2, showing a power outfit in operation.) Angles or elbows should be used on all spray rods so that "overshot" and "undershot" spraying can be done; that is, spraying from above downward, and from below up-

ward to reach the lower surface of the leaves. The trees should be drenched until they drip freely.

Especial care should be taken with the outside fruit as the thrips scar this badly, but cause little or no injury to inside fruit.

Either chamber nozzles of the Cyclone type or Bordeaux nozzles may be used. If the former are used, disks with holes of about $\frac{3}{32}$ inch diameter will be best. Double nozzles can be used to advantage on large trees, and will save time. It is preferable to use two lines of hose as this will insure more thorough work than where four leads are used. A majority of orange growers fail to apply a sufficient number of gallons of spray per tree. The following table will show approximately the correct amount to apply, and will enable those intending to spray to estimate the quantity of spray material needed for the season:

TABLE IV.—*Quantities of liquid required in spraying for orange thrips.*

Age of trees.	One application.		Total gallons of diluted spray per acre of 100 trees, 4 applications.
	Gallons diluted spray per tree.	Gallons per acre of 100 trees.	
Years.			
2–3.....	2	200	800
5–7.....	4	400	1,600
8–10....	5	500	2,000
12–14...	8	800	3,200

SUMMARY.

The orange thrips, a minute, orange-yellow insect of the order Thysanoptera, curls the leaves and scars the fruit of citrus trees in the San Joaquin Valley of California, the southern California orange belt, and the Salt River Valley of Arizona.

Although this insect has been known by its work for some fifteen or sixteen years it has but recently been described, and it has now become of serious economic importance in the orange belt of the San Joaquin Valley of California.

The orange thrips has numerous generations yearly, its life cycle requiring approximately 20 days, and it is to be found upon the orange trees from March to November.

It can be controlled by four sprayings of lime-sulphur solution combined with a commercial tobacco extract, which should be applied when the thrips become sufficiently numerous. Three applications should be made in the spring months to save the fruit and spring

growths from injury, and one in the fall to lessen the feeding injury to the fall growth of the orange trees.

From two to eight gallons of this combination spray should be applied per tree, at a high pressure, and in a very thorough manner, as only thrips that are hit will be killed.

Experiments in spraying have shown that three thorough applications at the proper times have resulted in from 20 per cent to 60 per cent more "fancy" fruit in the sprayed as compared with the unsprayed blocks.

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PAPERS ON INSECTS INJURIOUS TO CITRUS AND OTHER SUBTROPICAL FRUITS.

THE RED-BANDED THRIPS.

(*Heliothrips rubrocinctus* Giard.)

By H. M. Russell,

Entomological Assistant.

INTRODUCTION.

For a period of about twelve years the red-banded thrips (*Heliothrips rubrocinctus* Giard) (Pl. V) has ranked as an important insect enemy of the cacao in the West Indies, where it is known as the "cacao thrips."[a] Recently it has obtained a foothold in Florida, where at the present time it occurs at several widely separated localities adjacent to the East Coast, attacking principally the mango and avocado. The list of food plants of this insect embraces a number of different species, and as the cacao, from which its tropical name, the cacao thrips, is derived, is not at present grown to any extent in the United States, the writer has called it the red-banded thrips, one of the most noticeable characteristics of the species being the bright-red cross-band which in all stages decorates the middle of the body.

The writer, when stationed at Miami, Fla., during 1909, made a few observations on this species, and it has seemed best to publish them in this preliminary account, in order that growers may be prepared to combat this new enemy, which has already caused great damage in certain islands of the West Indies, and which will, if neglected, undoubtedly prove a serious pest in this country. It is hoped that this paper may serve also to keep the growers of California on their guard, since the introduction of this thrips might result injuriously to the culture of the guava and avocado in that State.

HISTORY.

This thrips was first described as *Physophus rubrocincta* by August Giard[3b], in 1901, from specimens received from Guadeloupe, French

[a] Mr. Charles S. Banks in 1904, in Bul. No. 1, Entomological Division of the Bureau of Government Laboratories of the Philippines, page 30 and figs. 32 and 33, records a black thrips as injuring cacao. This thrips, however, as shown by his figure, belongs to the suborder Tubulifera and resembles in its injury *Mesothrips ficorum* Marchal Craw., which causes injury to various species of Ficus in Key West, Cuba, and Porto Rico. Where the leaves of these plants are attacked by this insect they curl up and the insect hides within in great numbers.

[b] See Bibliography, p. 28.

West Indies, where it had been the cause of considerable damage to the cacao. Giard published some account of its damages and stated that it was the same species that Maxwell-Lefroy[2] had recently reported as injuring cacao in the island of Grenada. In this report Maxwell-Lefroy considered the conditions then existing in Grenada and gave an account of the spraying experiments against this insect. Probably the first mention of this insect was that of W. E. Broadway,[1] in 1898, when attention was called to the "blight" of the cacao.

A. Elot,[4] in 1901, gave a very clear account of the injury caused by this insect and of its habits and republished the description of Giard. According to this writer the different stages fed on the foliage and pods of the cacao and caused damage not only by destroying the leaves but by so changing the appearance of affected pods that it was impossible to distinguish them from the mature pods; thus great damage resulted from picking the pods prematurely.

In 1902 an editorial review[5] of this article by Elot appeared in a West Indian Bulletin, and also one by W. Fawcett[6] on the work of Maxwell-Lefroy appeared in a bulletin of the botanical department of Jamaica. During 1903 and 1904 several short articles were published, and these are given in the bibliography.

In 1905 A. Elot [13] published another article on the injury to cacao by this thrips. In this he repeated a good part of the information used in his former article. He stated that cultivation, pruning and fertilizing would be very beneficial to trees attacked by this insect.

The next year H. A. Ballou [14] published a short article on *Physophus rubrocincta*, which was largely abstracted from the earlier one of Maxwell-Lefroy. This same writer between 1906 and 1909 published a number of short articles that are listed in the bibliography.

Mr. H. J. Franklin,[18] in 1908, published an article in which he redescribed the female and also described the male for the first time. He recorded it as feeding on cacao and kola in St. Vincent Island, and also published a bibliography of the species.

In 1909 [20] Maxwell-Lefroy reported that it occurred in Ceylon, and that it was probably introduced into the West Indies from there.

F. W. Urich,[21] in 1910, reported a serious outbreak during November and December in the island of Trinidad. The same author,[24] in February, 1911, published a bulletin on this insect. He gave very good colored plates showing the adult, larva, and pupa, and the appearance of injured leaves and pods of the cacao. The different stages and habits were described and the life history studied to some extent for the island of Trinidad. Urich recorded it as feeding on the cacao, guava, roses, almond, and mango.

J. E. Higgins,[25] in 1911, recorded it as injuring mango seedlings in the greenhouses at the Hawaii Agricultural Experiment Station.

This account of the history of the red-banded thrips takes up only the more important notices that this insect has received. For further information see the bibliography (p. 28) or the article by Urich [24] published in 1911.

RECENT RECORDS.

On March 28, 1900, specimens of the larva, pupa, and adult of this insect were received by this bureau from Mr. D. Morris, of Barbados Island. He stated that they were collected in Dominica on cacao. On October 5, 1900, another lot, from Grenada, British West Indies, was received from Mr. Morris. Mr. P. J. Wester, formerly of the Bureau of Plant Industry, during the winter of 1908 sent to the Bureau of Entomology, from Miami, Fla., several lots of mango leaves badly injured by *Heliothrips rubrocinctus* Giard and *Heliothrips hæmorrhoidalis* Bouché, working together. He wrote that previous to that time they had not seemed to cause much damage. The writer, during January and February, 1909, found these two insects at Miami, Fla., working together in large numbers on the leaves of the mango and the avocado. Mr. Edward Simmonds, on November 1, 1911, sent a number of mango leaves from Miami, Fla., that were quite badly infested.

August 6, 1912, Mr. H. L. Sanford collected specimens of the adult, larva, and pupa, in the greenhouses of the Department of Agriculture, at Washington, D. C. The insects were seriously attacking mango plants received from the island of Mauritius.

NATURE AND EXTENT OF INJURY.

Injury by the red-banded thrips is similar to that of the greenhouse thrips (*Heliothrips hæmorrhoidalis* Bouché)[a] and of the bean thrips (*Heliothrips fasciatus* Pergande),[b] and is likewise caused by the manner in which these insects obtain their food. The present thrips is treated here as an enemy to the mango and avocado (alligator pear) only, as cacao is not at present of importance as a crop in this country. The adults and larvæ feed together on the same foliage and injure this in the same way. The epidermis is first pierced by the sharp mouthparts and then the leaf tissue within is rasped or scraped out, leaving a minute spot where the chlorophyll or green content of the leaf has been removed. This spot becomes brown. These spots become very abundant and after a while run together, forming large brown patches near the main or side veins, the leaves later turning brown and drying up. In severe cases the entire leaf surface is

[a] For description of injury by the greenhouse thrips see Bul. 64, Pt. VI, Bur. Ent., U. S. Dept. Agr., p. 44, 1909; also Cir. 151, Bur. Ent., U. S. Dept. Agr., 1912.

[b] For description of injury by the bean thrips see Bul. 118, Bur. Ent., U. S. Dept. Agr., 1912.

infested, and in such cases the larvæ move around to the other side and feed. Thus the function of the leaf is entirely destroyed and the leaves dry up and often fall. (See Pl. IV.) In feeding, this thrips excretes over the surface of the infested leaves a reddish fluid in small spots, which hardens and turns black. Although it has not been observed on the fruit, it is probable that in cases of severe attack this insect will also attack the fruit of the mango and avocado in the same manner that it does the pods of cacao. If such a condition should result, it will produce even greater loss, since the value of these high-grade fruits will be greatly reduced. The effect of the feeding is graphically shown in Plate IV, where the leaf on the left is uninjured and the leaf on the right has been infested by thrips.

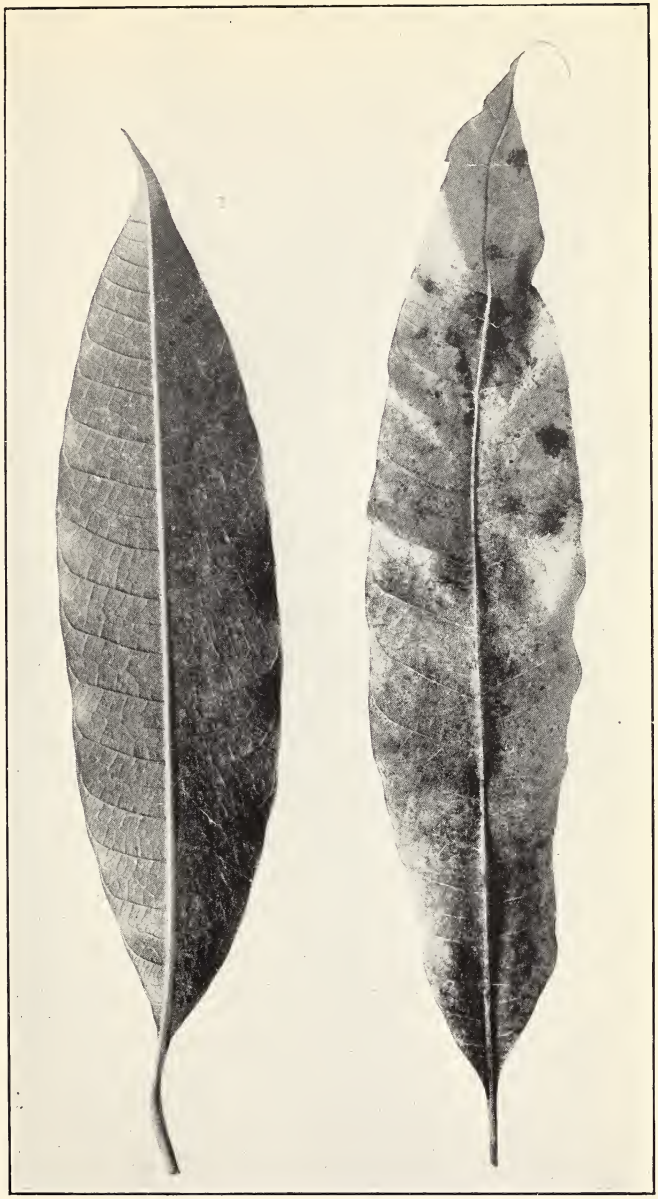
ORIGIN AND DISTRIBUTION.

Heliothrips rubrocinctus was originally described from specimens collected in the island of Guadeloupe, French West Indies. At about the same time it was observed to be injuring cacao on islands of the British West Indies—Grenada, St. Vincent, St. Lucia, and Dominica. Maxwell-Lefroy, in Indian Insect Life, wrote: "*Physophus rubrocincta* Giard is a serious pest to cacao in the West Indies, to which place it was probably introduced from Ceylon." There has been some question as to whether the thrips which injures cacao in Ceylon is this same species, but as the author quoted above was one of the first to study this species in Grenada it is hardly probable that he would mistake another insect for it, provided he saw the insect in Ceylon that he refers to this species.

This thrips occurs also in Trinidad, the island of Tobago, the Virgin Islands, and the Uganda, and within the past year has been recorded from the Hawaii Experiment Station greenhouses in Honolulu.

In the United States it is confined to a short strip of the Florida east coast centering in Miami. As it is a tropical species, it will probably not spread north of Florida; therefore, unless it obtains an entrance into California or into greenhouses in the North the distribution in our own country will be limited. This insect has been taken in one of the greenhouses of the Department of Agriculture on plants from Mauritius. At present it is quite widely distributed in the tropical islands of the Atlantic and Pacific Oceans, and its original home was, without a doubt, in some of these islands. It may have first come from Ceylon, as Maxwell-Lefroy suggests, or its original home may be in the West Indies. Its habitat is the Tropical Life Zone, as designated by Dr. C. Hart Merriam.[a]

[a] Life Zones and Crop Zones of the United States. Bul. 10, Biol. Surv., U. S. Dept. Agr., 1898.



LEAVES OF THE MANGO (MANGIFERA INDICA), SHOWING INJURY BY THE RED-BANDED THRIPS (HELIOTHRIPS RUBROCINCTUS).

The leaf on the right is badly injured by the feeding of the thrips, while the leaf on the left is uninjured. (Original.)

CLASSIFICATION.

When first described this insect was put in the genus Physophus and remained there until 1908, when Franklin placed it in the genus Heliothrips because of its structure. H. Karny [a], in a revision of the genus Heliothrips, made this species the type for a new subgenus, Selenothrips. However, for the present, the writer prefers to refer it to the genus Heliothrips in its old sense. This species is readily placed in this genus by reason of the downward curved ovipositor, the reticulated structure of the body, and the 8-segmented antennæ with segment 8 longer than 7, and the spines on the wings pointed.

DESCRIPTION.

THE ADULT.

(Pl. V, fig. 1.)

As an adult this insect can be separated from others associating with it by the characters given above and by the black body, dark wings, the reddish band, evident in the first three segments of the abdomen, and the red color of the anal segment. The adult female (Pl. V, fig. 1) is about one twenty-fourth of an inch long (1.1174 mm.) and quite stout. The color is dark brown or black.[b] The male is much smaller and is apparently not very commonly collected. When the adults first emerge, the colors of the body are light, but in a short time these darken and the mature colors appear.

THE EGG.

The egg was not observed by the writer, but was described by F. W. Urich,[24] as follows:

> As dissected out of the female the egg is kidney-shaped, 0.255 mm. long and 0.105 mm. wide, with a very thin shell and transparent.

The eggs are inserted by the female into the tissues of the mango or avocado leaves and in the case of the cacao, as observed by Urich, in the leaves and pods of the bean as well.

THE FIRST-STAGE LARVA.

The following description was made while the larva was less than a day old and before it had begun to feed:

> Length about 0.25 mm. and nearly six times as long as wide. General shape fusiform; head, antennæ, and legs very large in proportion. Head quadrate, rounded in front, light yellow in color; ocelli absent, eyes red, antennæ seven-jointed, hyaline; legs and body hyaline; segments 1 and 2 of abdomen crossed by a bright red band, anal segment red; end of abdomen with four long hairs about four times as long as segment 10.

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[a] Ent. Rundschau, Jahrg. 28, pp. 179–181, December, 1911.

[b] For full description of this species see Franklin's paper, [18] pp. 719–723.

THE SECOND-STAGE OR MATURE LARVA.

(Pl. V, fig. 2.)

Length 1.0117 mm.; width of mesothorax 0.2718 mm. Body long and cylindrical, the head and thorax considerably narrowed, and the abdomen gradually converging to the end. Color of thorax and abdomen translucent white to orange-yellowish. Contents of the alimentary tract showing through as a greenish mass extending from the mesothorax to the fifth abdominal segment; the posterior half of segment 1 and all of segments 2 and 3 of the abdomen bright red; last segment of the abdomen also bright red. Surface of the body covered with minute granules and with numerous short setæ which are black in color and swollen at the tips. Head 0.0906 mm. in length, 0.1559 mm. in width, front rounded and sides bulging considerably, constricted behind the eyes to a distinct neck. Eyes made up of a few large facets, red, no ocelli present. Antennæ seven-segmented, about 0.3473 mm. long; segments 3 and 4 long, slender, spindle-shaped, and annulated; 5 short, cylindrical; 6 longer than 5, slender, cylindrical; 7 slightly longer than 6, very slender; near the distal end of each segment are a number of setæ. Prothorax with the anterior margin considerably narrower than the posterior, sides rounded, a pair of setæ on each side, a pair on dorsum near anterior margin, and another pair near posterior margin. Mesothorax and metathorax with a number of setæ near sides and a pair of spiracles on the anterior mesothoracic angles. Legs translucent white. Abdomen 0.6795 mm. in length, 0.3473 mm. in width, fusiform, no evidence of ovipositor in female larva, a pair of spiracles on the sides of segments 2 and 9; segments 9 and 10 about equal in length, 10 with four long, stout setæ, 0.2265 mm. in length. Segments of abdomen bearing longitudinal rows of setæ at sides, just within outline, and two incomplete rows on the dorsum.

THE YOUNG NYMPH OR PREPUPA.

(Pl. V. fig. 3.)

Length 1.087 mm.; width of mesothorax 0.2567 mm. Shape fusiform, similar to that of the adult. Head length 0.1057 mm.; width at the eyes 0.1812 mm. Head rounded in front and on angles so that the sides bulge strongly, sides strongly converging to posterior margin. Head translucent white, more or less blotched with orange; eyes red or orange, not large; ocelli absent; a pair of setæ behind the eyes, another pair between the eyes, and a third pair back of pair 2 more widely separated. Antennæ 7-segmented, translucent white, except segment 1, which is orange, extending forward about twice the length of the head; segment 1 cylindrical, broader than long; segment 2 cylindrical, narrowed at distal end, about twice as long as 1 and not so broad; 3 about as long as 2, more slender, base constricted; 4 shorter than 3, somewhat rounded and constricted at the base; 5 as long as 3 and 4 together, slender cylindrical; 6 short cylindrical and not as stout as 5; 7 cylindrical, longer than 6, and tapering at the tip; a few setæ present on the segments. Prothorax more than twice as wide as long; sides rounded, with the posterior margin the widest; translucent white, marked with orange; three setæ on each side, that at posterior angle longest, and four setæ in a transverse row on the dorsum near the anterior margin. Mesothorax with prominent angles, translucent white, with some orange on the dorsum. Wing cases translucent white, distinct from each other; those of the fore-wing extending to the posterior edge of segment 2 of the abdomen, and those of the hind wings extending to beyond anterior edge of segment 3. Legs translucent white to faint yellow, strong, with a number of white setæ. Abdomen fusiform like that of the adult, translucent white to yellowish orange, with a bright red band on posterior half of segment 1 and on all of segments 2 and 3 (in some examples, dashes of red on side of 2 or segments following), last segment also bright red. Abdomen with about six longitudinal rows of white setæ increasing in length toward the posterior end of the body. Length of the abdomen 0.6644 mm.; width 0.2869 mm.

THE FULL-GROWN NYMPH OR PUPA.

(Pl. V, fig. 4.)

Length 1.017 mm.; width at mesothoracic angles 0.2567 mm.; shape similar to adult. Color translucent white to yellowish orange, first three segments and last segment of the abdomen bright red. Head 0.1208 mm. in length, 0.1963 mm. in width; white, with more or less orange (in older pupæ surface distinctly reticulated); eyes oval, dark red, larger than in prepupal stage, facets large; three ocelli present in close triangle between the eyes in older pupæ, white, surrounded by orange. Antennæ laid backward on head and reaching to beyond anterior edge of mesothorax; segments indistinct, transparent white; segments 1 and 2 projecting more or less forward and upward; on segment 2 a long slender seta, 0.1208 mm. in length, projecting forward.

Thorax (very plainly reticulated in older pupæ) translucent white, with some yellowish orange on mid-dorsal region. Prothorax 0.1057 mm. in length, 0.2114 mm. in width, sides rounded. The entire body well supplied with setæ, those on posterior angles of prothorax, on wing-cases, and on sides of the abdomen quite long. Wing-cases 0.4934 mm. in length, extending to beyond anterior margin of segment 6 of the abdomen, translucent white to faint yellow. Length from head to end of wing-pads 0.755 mm. Legs translucent white, very plainly reticulated in older pupæ. Abdomen fusiform, surface reticulated in older pupæ, general color translucent white to yellow with the first three segments and the last bright red; in some examples a patch of bright green was observed, caused by food in the alimentary canal. Length of abdomen 0.5889 mm.; width 0.302 mm.; length of posterior setæ 0.906 mm.

HABITS OF THE ADULT.

The adults are found feeding on both the surface and underside of the foliage. In many cases they are to be found mingling on the same leaf with *Heliothrips hæmorrhoidalis* Bouché. The adults also are found feeding in a colony with the pupæ and larvæ, all in close proximity to each other. They feed on the leaf content as do other thrips, and in many cases rest alongside the leaf vein or under the webs of the red spider. If disturbed or alarmed these insects were observed to make long quick jumps or to crawl rapidly over the leaf much faster than *Heliothrips hæmorrhoidalis* ever moves. There is another peculiar trait possessed by members of this species, namely, that the adults are often observed crawling on a leaf with the abdomen lifted and curved forward over the body. They are apparently very sensitive to cold, as adults that were placed on a cake of ice became motionless at once, but began to move actively again within a short time after removal.

This species, like *H. hæmorrhoidalis*, selects the tender young foliage to feed upon, and while doing so the female deposits the eggs in the leaf. After the female has deposited each egg she seals the opening with a large drop of excrement which dries to a flat scale so that the egg-pocket is concealed. As these leaves begin to become exhausted from the excessive feeding of the adults and larvæ that have hatched, the adults forsake them and attack the newer leaves of the plant. While this insect was under the observation of the writer, flight

was never observed, but Urich [24] observed it in flight in the cool of the evening. The writer has never observed the male and it seems to be quite rare, as Urich observed it on only a few occasions. Reproduction for portions of the year is parthenogenetic, but at other times bisexual. The adults seem to be very sensitive to lack of moisture and die rapidly in breeding vials. On mango trees in the greenhouse individuals have been observed to live as adults for from 14 to 17 days, when, although still very active, they were lost. Probably this adult has a more extended period of life as the author has kept specimens of a related species, *Heliothrips fasciatus*, alive for three months.

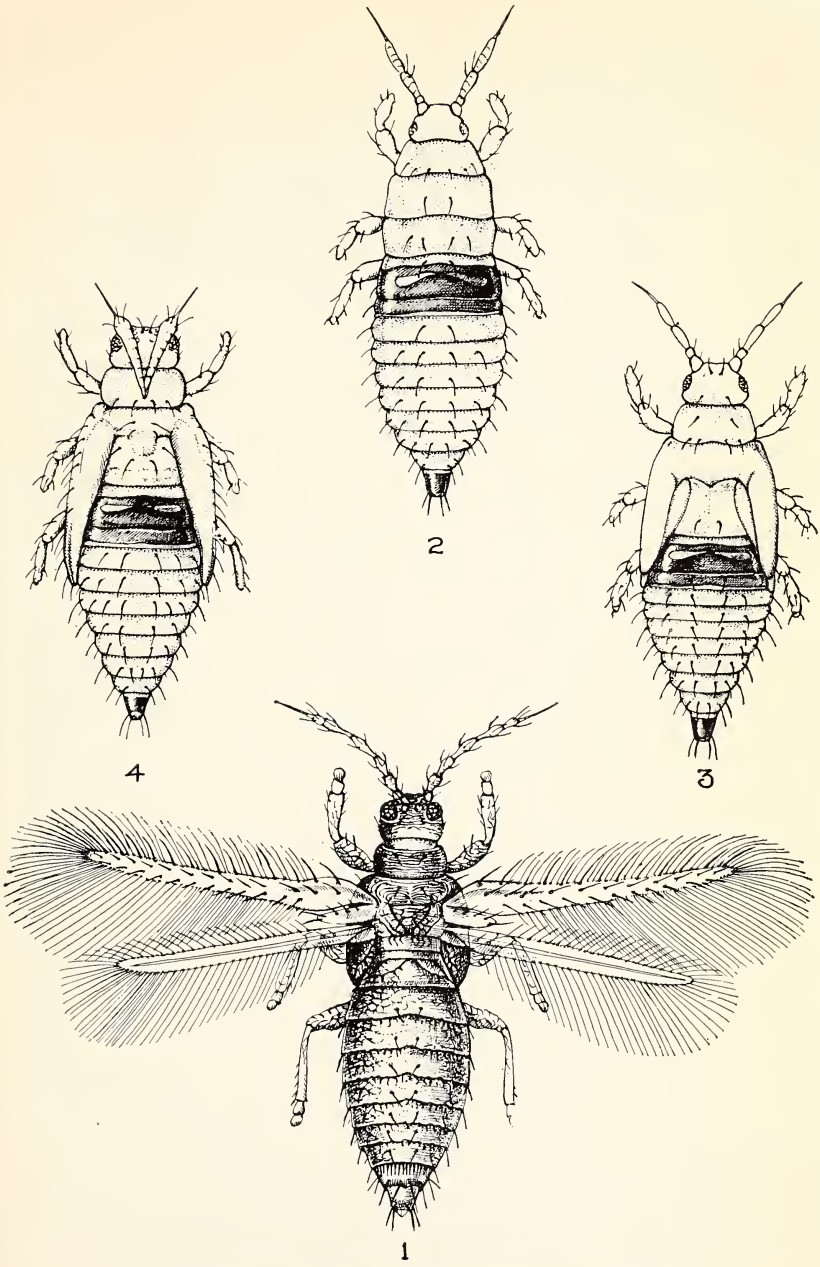
HATCHING OF THE EGG.

The eggs, as they near the end of the period of incubation, become considerably swollen, so that if the scale covering each egg is removed there is a slight elevation of the leaf noted. The larva hatches by the same process as that used by *Heliothrips hæmorrhoidalis*, but emerges from under the dried scale at one side, and in many cases, as it moves away, carries this scale on its back.

HABITS OF THE LARVA.

The larvæ feed on the leaves in company with the adults and generally prefer the underside, but the writer has frequently observed them in large numbers on both sides of the leaf. They feed clustered together in colonies, in folds of the leaf, or along the main vein, or even under red-spider webs. As they feed, the leaf becomes full of minute brown spots where the chlorophyll has been extracted, and in severe cases these run together and the entire leaf becomes brown and dried up. At all times the larva holds the tip of the abdomen in the air and bears a drop of reddish liquid, which is held more or less in place by the stout anal hairs. As this increases in size it falls to the leaf and the surface becomes covered with drops of excrement, as occurs with plants affected by *Heliothrips hæmorrhoidalis*. The larvæ when disturbed crawl rapidly away, or, if exposed to the light, endeavor to reach the shade again. In some cases the molted skin was observed being carried on the tip of the abdomen, but this may have been accidental.

The larvæ when full grown cluster in a fold of the leaf, near the midrib or under the web of a red spider, to change to prepupæ. The skin at the head then splits and gradually, by contractions of the body, the prepupæ work their way out. When they have emerged they leave the empty skins on the leaf, or in some cases carry them around on the end of the abdomen.



THE RED-BANDED THRIPS (HELIOTHRIPS RUBROCINCTUS).

Fig. 1.—Adult female. Fig. 2.—Full-grown larva. Fig. 3.—Prepupa. Fig. 4.—Pupa. (Original.)

HABITS OF THE PREPUPA AND PUPA.

The prepupæ remain clustered so closely that they almost touch each other and are almost motionless. However, if alarmed or disturbed they move rapidly away. At all times they carry the antennæ, which are freely motile, out in front of the head. The prepupæ change to the pupæ in among the colony of prepupæ and larvæ on the leaf. When the prepupa is ready to molt, the skin is ruptured over the head and gradually worked off at the posterior end by contractions of the body, and the cast skin is left behind on the leaf.

The pupæ, while they possess the power of motion, are more sluggish, and will not move around unless disturbed or exposed to a strong light. They carry the antennæ folded back over the head onto the prothorax. In recently formed pupæ the reticulations on the body are absent, as also are the ocelli; but as the pupæ develop, the ocelli gradually appear between the eyes and the reticulations gradually become evident, until they are extremely heavy and distinct. As the pupæ become nearly mature, the body begins to turn darker, until just before emergence of the adults the pupæ are almost black. The adults emerge from the pupæ in the same manner that the younger stages molt; they then move away for a short distance and remain more or less motionless until the chitin hardens. Within a day the full colors have developed and the adults begin feeding.

FOOD PLANTS.

In Florida this insect has been found feeding on the avocado (*Persea gratissima*) and mango (*Mangifera indica*), causing serious injury to these plants.

Maxwell-Lefroy recorded it on cashew, guava (*Psidium guajava*), cacao (*Theobroma cacao*), and Liberian coffee (*Coffea liberica*), and Ballou recorded it on the wild guava (*Anacardium occidentale*) and cotton. Urich recorded it as feeding on the cashew, cacao, guava, roses, the Mexican almond or umbrella tree (*Terminalia catappa*), and mango. Franklin also recorded its occurrence on the cacao and kola (*Sterculia acuminata*).

LIFE CYCLE.

The writer has worked out the complete life cycle of this insect in the greenhouse at Washington, but for lack of time failed to follow it through successfully while in the field at Miami. In the greenhouse the egg required from 15 to 16 days for incubation, with an average mean temperature of 77° to 78°. (See Table I.)

TABLE I.—*Length of the egg stage of Heliothrips rubrocinctus, Washington, D. C., 1912.*

Experiment No.	Date of oviposition.	Eggs hatched on—	Minimum length of stage.	Maximum length of stage.	Average mean temperature.
			Days.	*Days.*	° *F.*
1.....	Apr. 11	Apr. 26 (1).....	15	.....	78.78
2.....	Apr. 14	Apr. 29 (2).....	15	16	77.1
		Apr. 30 (1).....			

From leaves picked in Florida on April 3 the larvæ continued to emerge until April 12, giving a minimum length in this case at Miami of at least nine days.

The length of the egg stage was not determined by the writer for Florida. Urich found that on the island of Trinidad the eggs hatched for three days after they were picked and freed of the adults, but made no exact determination on the length of incubation. The length of the egg stage in Florida will be very similar to that of *hæmorrhoidalis*, or from 8 days as a minimum to 16 or 17 days as a maximum as observed by the writer in the greenhouse.

In the greenhouse a number of experiments were conducted and gave a length of the larval stage of from 8 to 16 days, with average mean temperatures of 68° to 76° F. (See Table II.)

TABLE II.—*Length of larval stage of Heliothrips rubrocinctus in greenhouse, Washington, D. C., 1912.*

Experiment No.	Date larvæ hatched.	Number hatched.	Date first larva pupated.	Date last larva pupated.	Number pupated.	Minimum length of stage.	Maximum length of stage.	Average mean temperature.
						Days.	*Days.*	° *F.*
1	Apr. 3	28	Apr. 11	Apr. 18	20	8	15	68.88
2	...do.....	10	...do.....	Apr. 13	6	8	10	[1] 76.08
3	Apr. 6	6	Apr. 17	Apr. 22	3	11	16	68.5

[1] Records missing for first four days, but would probably not alter the average mean temperature more than a degree either way.

In Trinidad the larval period requires six days for development. The temperatures were not stated, but were probably quite high, as the growth was very rapid. In Florida the larval period will probably occupy from 6 to 20 days, depending upon the temperature and humidity.

Urich found that the prepupal stage required one day and the pupal stage two days for development. During the month of November, with a moderately cool temperature, in a greenhouse, the writer found that the prepupal stage required from one to two days and the pupal stage from two to six days.

A large number of prepupæ, under observation in the greenhouse in April, 1912, were found to require from one to four days for devel-

opment before changing to pupæ, with an average mean temperature of about 71° F. (See Table III.)

TABLE III.—*Length of prepupal stage of Heliothrips rubrocinctus in greenhouse at Washington, D. C., April, 1912.*

Experiment No.	Date larva changed to prepupa.	Number changed to prepupa.	Date prepupa changed to pupa.	Number changed to pupa.	Minimum length of stage.	Maximum length of stage.	Average mean temperature.
					Days.	*Days.*	° *F.*
1	Apr. 11	2	Apr. 12	2	.....	.....	71.5
	Apr. 13	1	Apr. 15	1	1	2	.....
2	Apr. 12	1	Apr. 16	3	3	4	72.35
	Apr. 13	2	.....	.....	.....	.....	.....
3	Apr. 11	5	Apr. 13	3			
	Apr. 12	2	Apr. 14	3	1	2	70.75
	Apr. 15	6	Apr. 16	5			
	Apr. 16	3	Apr. 18	2			
4	Apr. 17	.....	Apr. 20	1	3	.....	[1] 68
	Apr. 20	.....	Apr. 23	1	.....	.....	.....

[1] Approximate.

A number of pupæ in the greenhouse required from four to seven days for development, with an average mean temperature of from 68° to 70° F.

TABLE IV.—*Length of pupal stage of Heliothrips rubrocinctus in greenhouse at Washington, D. C., April, 1912.*

Experiment No.	Date prepupa changed to pupa.	Number changed to pupa.	Date pupa changed to adult.	Number changed to adult.	Minimum length of stage.	Maximum length of stage.	Average mean temperature.
					Days.	*Days.*	° *F.*
1	Apr. 12	2	Apr. 16[1]	1	.....	.....	.....
			Apr. 16[2]	1			
	Apr. 13	3	Apr. 17	2	4	5	70.75
			Apr. 18	1	.....	.....	.....
2	Apr. 13	3	Apr. 19	1	.....	.....	68.5
			Apr. 20	2	.....	.....	.....
	Apr. 15	3	Apr. 20	1	4	6	68.57
			Apr. 20	2	.....	.....	.....
	Apr. 22	2	Apr. 27	1	.....	.....	69.37
3	Apr. 20	1	Apr. 24	1	4	.....	69.75
4	Apr. 16	3	Apr. 21	2	6	7	67.5
			Apr. 22	1	.....	.....	.....

[1] 9 a. m. [2] 1 p. m.

In Trinidad this thrips requires 12 days from the time the egg hatches until the adult appears, and with an estimated period of 4 to 6 days for the egg stage the life cycle will be approximately 16 to 18 days. Observations in a greenhouse at Washington, D. C., gave a total life cycle of 28 days as a minimum to 43 days as a maximum, with an average mean temperature of about 70° F. In Florida the life cycle may require only 20 days as a minimum, but during parts of the year at least will require in some cases 43 days for the complete life cycle and possibly even longer. This insect will probably have at least 10 generations annually in Florida.

NATURAL CONTROL.

Rains.—The heavy summer rains that occur in Florida are directly responsible for the destruction of large numbers of this thrips.

The author did not observe any natural enemies feeding on this thrips. However, as *Triphleps insidiosus* Say feeds quite commonly on *Heliothrips fasciatus* in California, it will probably be found to attack the present species.

ARTIFICIAL CONTROL.

Where this insect becomes sufficiently abundant to cause injury to the mango and avocado, it can be controlled by careful spraying with a nicotine extract. Mr. Edward Simmons, at the subtropical gardens of the Bureau of Plant Industry, has controlled it during the last two years by spraying according to the following formula:

Blackleaf tobacco extract	gallon..	1
Whale-oil soap	pound..	1
Water	gallons..	50

First dissolve the soap in a quantity of water, then add the blackleaf tobacco extract and full amount of water and thoroughly mix. This spray should be applied to the trees at a good pressure, so as to thoroughly coat the surface and underside of the leaves.

Another formula that will give equally good results is the following: Take 1 part of blackleaf tobacco extract containing 40 per cent nicotine solution to 1,500 to 2,000 parts of water and add 1 pound of whale-oil soap to every 50 gallons of the mixture and thoroughly spray the foliage.

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